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EVALUATION OF SOIL MECHANICS LABORATORY EQUIPMENT. REPORT NO. 2--ETC(U)  
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EVALUATION OF SOIL MECHANICS LABORATORY EQUIPMENT.  
REPORT NO. 2. EVALUATION OF KAROL-WARNER CONBEL  
CONSOLIDATION LOADING DEVICE

ARMY ENGINEER WATERWAYS EXPERIMENT STATION,  
VICKSBURG, MISSISSIPPI

MAY 1960

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# EVALUATION OF SOIL MECHANICS LABORATORY EQUIPMENT

## EVALUATION OF KAROL-WARNER CONBEL CONSOLIDATION LOADING DEVICE

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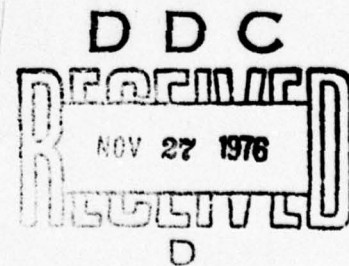


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#### PREFACE

This investigation was conducted for the Office, Chief of Engineers, as directed in letter dated 5 February 1957, ENGWE, subject "New Civil Works Investigation Project." The project was designated "Evaluation of Soil Mechanics Laboratory Equipment (CW-516)."

This report is the second in a series on the evaluation of soil mechanics laboratory equipment. The first report, "Warlam Triaxial Apparatus for 6-in.-Diameter Samples," was distributed at the Division Laboratories Conference in November 1958.

The work was performed by personnel of the Soils Test Section, U. S. Army Engineer Waterways Experiment Station, under the supervision of Messrs. W. J. Turnbull and W. G. Shockley, Chief and Assistant Chief of the Soils Division, respectively. This report was prepared by Mr. J. E. Mitchell.

Director of the Waterways Experiment Station during the conduct of this investigation and preparation of this report was Colonel Edmund H. Lang, CE. Mr. J. B. Tiffany was Technical Director.

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1.

EVALUATION OF KAROL-WARNER CONBEL  
CONSOLIDATION LOADING DEVICE

PART I: INTRODUCTION

1. Source and cost. The equipment is manufactured by Karol-Warner, Inc., 432 Cedar Avenue, Highland Park, New Jersey. The cost was \$902.25 F.O.B. Vicksburg, Mississippi.

2. Application. The apparatus is designed primarily to apply loads on a soil sample in the consolidation test. The device can be used to apply and maintain any load up to the capacity of the machine, which is 6000 lb for the model tested. Figure 1 is a photograph of this model. Other models are available with capacities from 680 to 10,000 lb total load. The larger models are similar in construction and operation to the model tested, as described in Part II of this report, and their performance should therefore be similar. The smaller models are different in design and probably would not have the same performance characteristics; however, for purposes of this evaluation it was felt that the larger models would be more applicable to division laboratories testing than the smaller models. The smaller models apply the load by means of regulated air pressure through an oil-air accumulator. The oil flows from the accumulator into a metallic bellows which is free to move upward. The consolidometer is placed on this bellows for the application of load. In the larger models loading is accomplished by compressed air on a rubber diaphragm system attached to a piston. The piston transmits the force downward on the sample.

3. All models can be used for the application of stress-controlled loads in compression; loads can be applied quickly and maintained constant regardless of sample deformation during the loading period.



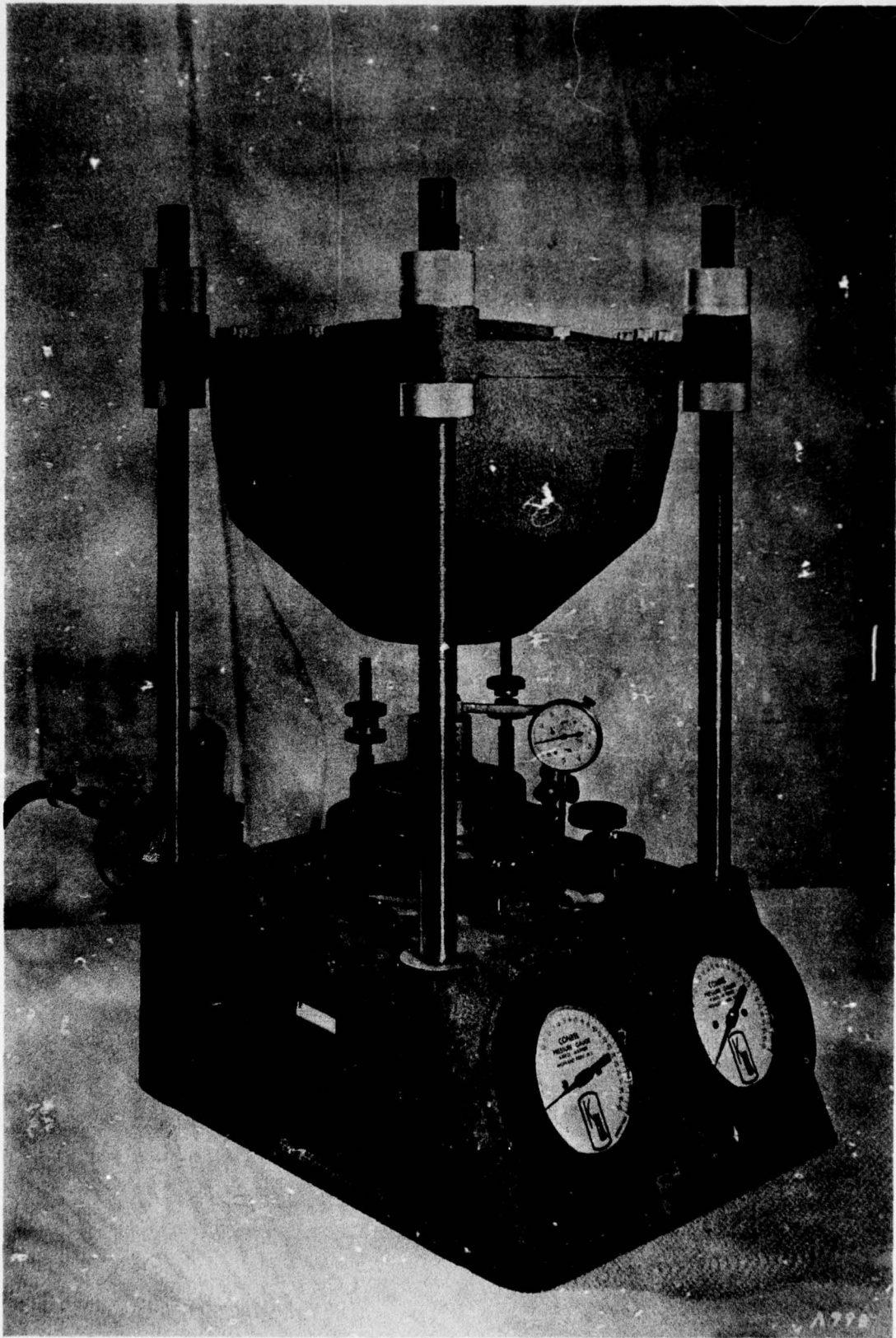


FIGURE 1

## PART II: DESCRIPTION OF APPARATUS

4. The unit purchased is Model 354 (fig. 1) which has a total load capacity of 6000 lb. This model was chosen for testing because it has sufficient load capacity for a standard 4-1/4-in.-diameter consolidation specimen. The use of aluminum castings for the base and diaphragm-piston housing results in a total weight of only 140 lb for the complete apparatus. Consolidation apparatus of comparable size using the lever loading deadweight system would weigh approximately 600 lb. The significantly lighter weight of the Conbel makes it particularly attractive for use in mobile laboratories where weight must be considered.

5. A space 14 in. wide, 18 in. long, and 29 in. high is required for the apparatus. For convenience of operation the equipment should be placed on a suitable table or on a support about table height. Critical leveling of the device is not required for satisfactory operation. This feature makes the Conbel apparatus especially suited for use in mobile laboratories.

6. Loading is accomplished by a rubber diaphragm system attached to a piston. This assembly is actuated by regulated compressed air. A steady supply of dry clean air at 80- to 150-psi pressure is required, depending on the load to be applied. Two load ranges are provided, a low range from 0 to 1600 lb total load on the piston and a high range from 0 to 6500 lb total load, and a quick-acting valve permits change from one load to the other. The load for each range is controlled by a separate pressure regulator with a Bourdon-tube pressure gauge to indicate the load applied. The faces of the pressure gauges have 300 divisions each; which is approximately 5 lb per division for the low range and 21 lb per division for the high range. The sensitivity is therefore limited to these values. From a set of calibration curves furnished by the manufacturer the gauge reading may be converted into total load in pounds on the piston. The low-pressure gauge must be closed off from the system with a hand valve when its capacity is



reached, as serious damage will result if the gauge is connected to the system when higher loads are applied. The loading is then increased with the high-pressure regulator and high-range gauge. Maintenance of a constant pressure with the type of regulator used in the machine depends upon bleeding. This results in an air consumption of 0.6 to 0.7 cu ft per minute at standard conditions under full load. The requirement for a constant supply of air is the most serious limitation of the device because it necessitates the use of a mechanical air compressor. The device is thus limited to use where there is a constant supply of air pressure or a reliable power supply to run an air compressor. The power required to maintain a supply of compressed air would be considerable and would add to the cost of operation where several devices are used.

7. The compressed air must be filtered to remove particles of dirt, rust, water, etc., which would interfere with proper functioning of the regulators. No filter was supplied with the equipment, and a Norgren, Series 21-B filter was purchased and used on the equipment tested. This is a two-stage filter composed of a cylindrical screen of 200-mesh Monel wire and an absorbent wound-cotton-yarn element. With the equipment in constant operation it is necessary to replace these yarn elements approximately every three days, depending on the relative humidity of the air. Therefore, spare elements are required. The elements may be dried out and reused several times before it becomes necessary to discard them.

8. The distance under the loading piston can be varied from 0 to 7 in. by adjusting the eight nuts which hold the diaphragm assembly on the four vertical threaded rods. This distance can be increased to 9 in. by removing the swivel head from the piston and replacing it with a fixed head. For some testing this might be an advantage.

### PART III: PERFORMANCE OF THE APPARATUS

9. Two calibration charts are supplied with the device, one for the low range and one for the high range. These charts convert pressure gauge readings into total load in pounds on the sample. Since the accuracy of loading is dependent upon the accuracy of these charts, they were carefully checked by using two calibrated proving rings, and were again checked later after a malfunction had been corrected in the machine. The proving rings were 0 to 500 lb and 0 to 7000 lb capacity. Both rings were carefully calibrated several times using various means of loading before they were used to check the apparatus.

10. To apply a load the piston was carefully brought into contact by opening the toggle valve, then gradually opening the low-range regulator until the proper reading was obtained on either the low- or high-range pressure gauge. At the desired time the toggle valve was opened and the load was quickly applied to the sample. This method of load application is according to the procedure given in the manufacturer's operating instructions (Appendix A of this report). Following this procedure, a series of loads was placed on the proving rings and the loads indicated by them were determined. A comparison of the loads as determined from the charts and from the proving rings is given in table 1. It is apparent that the loads as measured with the proving rings are usually lower than those determined from the chart. However, no definite trend could be established.

11. Following this calibration, several consolidation tests were performed to determine the operational characteristics of the equipment. No difficulties were experienced in these tests. However, several times the load on the sample was found to have increased or decreased about 5 lb from the value originally set on the gauge. This occurred only on loads less than 400 lb; above 400 lb no deviation of load with time was observed.



Table 1  
Calibration Data

<u>Conbel Gauge Reading</u>	<u>Load from Calibration Curve lb</u>	<u>Load from Proving Rings</u>	
		<u>1 Sep 59 lb</u>	<u>1 Mar 60 lb</u>
Low range:			
1.0	30	25	27
2.0	85	89	79
3.0	138	120	143
5.0	245	235	236
10.0	514	490	500
15.0	787	772	780
20.0	1051	1040	1040
25.0	1316	1325	1340
30.0	1585	1590	1605
High range:			
10.0	2130	2112	2170
15.0	3220	3187	3230
20.0	4300	4265	4260
25.0	5375	5362	5335
30.0	6450	6400	6495



12. A determination of the swelling pressure of a soil was made using the apparatus. No difficulties in operation were noted. The procedure used was to load the sample and consolidometer in the normal way and then to increase the loading gradually, using the low-range regulator until swelling of the sample was just prevented. Control of the loading was adequate for this test. At the completion of this test it was noticed that the low-range pressure gauge did not return to zero. The gauge was removed from the machine and disassembled and it was found that the hair spring on the movement was disarranged. The cause for this could not be determined. The Bourdon tube on the gauge was intact and did not appear to have been harmed by excessive pressure. The gauge was reassembled and placed in the apparatus and a new calibration curve was made. The results of this test (1 March 1960) are shown in table 1. The reason for change in calibration of the high range is not known. No malfunction of the high-range gauge was observed.

13. A word of caution should be given here about the danger of applying the pressure too suddenly to the gauges when going from the high range to the low range, even though the reduced pressure is within the low-range gauge capacity. The shock to the low-range gauge can be enough to dislocate the gauge hand on the pivot, and the impact on the moving parts of the gauge is severe and may cause damage. To avoid this the toggle valve should be operated slowly.

14. Once, during off-duty hours, one of the high-pressure plastic air lines came loose and released all the load on the sample. No other difficulties have been experienced with the connections for the plastic tubing.

15. The operation of the apparatus is rather erratic and not dependable for low loads (under 50 lb). The operating instructions furnished with the apparatus state that the sensitivity at low loads can be increased by slightly opening the bleeder valve. This operation was not found to affect the sensitivity significantly in the data obtained for this report. The bleeder valve must be closed when one load is changed to another; otherwise, the load is not maintained on the sample.

## PART IV: CONCLUSIONS

16. The equipment is compact and relatively lightweight; the Conbel weighs 140 lb compared to 600 lb for lever-loading apparatus of comparable capacity. The load is applied smoothly and without shock very easily and quickly. The load is held constant regardless of strain or deformation of the sample. The initial cost of the apparatus is somewhat higher than the lever and weight type units. The cost of the Conbel apparatus is approximately \$900 compared to \$700 for the lever type equipment.

17. The requirement for a supply of clean dry air under pressure makes it necessary to have an adequate compressor and a reliable source of essentially uninterrupted power to operate it. This power requirement would be an appreciable expense, especially where several units are operated. The requirement for air pressure is the most serious disadvantage in using the equipment in a mobile laboratory. The apparatus does not have to remain level constantly to operate as do the lever-type loading machines. This is advantageous in mobile laboratory or aboard ship installation.

18. The discrepancies between the loads measured by the proving rings and those determined from the calibration curve furnished by the manufacturer make it imperative that the apparatus be carefully calibrated before it is used.

19. From the performance observed thus far, it is believed that the pressure gauges should be protected from sudden fluctuations of pressure by the installation of snubbers in the connecting lines.



## APPENDIX A

DESCRIPTION AND OPERATING INSTRUCTIONS FURNISHED BY  
KAROL-WARNER, INC.

Conbel\*

1. The Karol-Warner Conbel is a hydraulic load applying machine intended for use in consolidation testing and stress controlled compression testing. Conbels are designed to apply instantaneously and maintain indefinitely any load within the limits of a particular model, regardless of sample compression occurring within the loading interval.

2. The major control components of a Conbel are, 1) a totally enclosed piston-diaphragm system, 2) an air regulator, 3) a pressure gage, and 4) control valves.

3. The piston-diaphragm system will, under normal usage, require no service throughout the life of the machine. The cover plate for the piston should not be removed, as this may destroy the perfect seal required at the edge of the diaphragm. The diaphragm itself is of rubber and placed in such a fashion that there is no spring constant throughout the piston travel.

4. The air regulator on the left side of the Conbel controls the air pressure acting on the piston, and consequently the load applied to the sample. A constant supply of air is required. This inlet air pressure should not exceed 150 psi, nor should it ever be less than 20 psi higher than the highest pressure that can be read on the Conbel gage. At any given setting the regulator will pass a constant air pressure, regardless of variations in supply pressure within the limits described above.

5. The stability of the regulator depends upon internal bleeding of air. At higher pressures this bleeding may become audible. This does

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\* Patents applied for.



not signify malfunction of the unit. At full output under dead end service the amount of air bled will approach 0.6 to 0.7 standard cubic feet per minute. This value may be used to determine the required compressor size for operating one or more Conbels.

6. When shut off completely, no air will pass through the regulator. Tiny particles of dirt in the air supply may lodge under the valve stem in the regulator and prevent complete shut-off. For this reason, it is recommended that the air supply be filtered.

7. Counterclockwise rotation of the regulator knob shuts off the passage of air. Clockwise rotation will increase the air pressure passed to the piston.

8. The pressure gage at the front of the Conbel is a laboratory test gage with a repeatability of  $1/4$  to  $1/2$  of one per cent. All Conbels have special faces graduated 0 to 30 by 300 divisions, and are provided with a reflector strip to eliminate parallax in reading.

9. The gage is intended for recording the pressure passed by the regulator, and must always be read in the same fashion for consistent results. Piping is so arranged that regulated pressure always shows on the gage, regardless of whether this pressure is acting on the piston. Conbels are calibrated by turning the air regulator knob so that the gage slowly moves up to the desired setting. It is recommended that gage settings always be made by approaching slowly from below, even on unloading sequences.

10. Due to the inertia present in the components of a Bourdon tube recording system, a sharp blow or vibration, and even a light tapping, may cause the gage needle to move from its preset position. This does not indicate a change in load, since load change can only be accomplished by changing the air regulator setting. Tapping of the gage should be resorted to at the start of a test when it is necessary to return the gage pointer to exact zero.

11. Two valves are provided to effect loading and unloading. These are both on the right side of the Conbel. Toward the front is a toggle valve, which controls the application of load to the piston. When the handle is up (vertical), the valve is open. When the handle is down (horizontal), the valve is shut. The handle may be rotated in a horizontal arc to a position most suitable to the operator.

12. The toggle valve is normally open during testing. It is shut only when it is necessary to change the sample load. After it is shut it will maintain the existing load on the sample, during the short interval necessary to reset the air regulator for the new load. When the toggle valve is reopened, the new load is instantaneously applied. (At this time the gage needle will jump rapidly due to air pressure differences between parts of the hydraulic system. Due to gage inertia, it may not return immediately to its preset position.)

13. Behind the toggle valve is a needle valve which is used for bleeding air from the piston. Clockwise rotation of the knob on this valve will shut it off. Normally, the bleeder valve should be shut. It is used for rapid unloading of the sample at the end of a test, and it may be used as an aid to increase the sensitivity of the air regulator, particularly at low loads.

#### Operating Instructions, Dual-Range Conbels

14. Make sure the air regulators are shut, then connect the Conbel to a steady supply of dry, filtered air. Supply pressure should not drop below 80 psi for Model 354, nor below 125 psi for Model 355.

15. Adjust the loading head until load plate and the consolidometer are in contact, then zero the dial indicator for measuring consolidation. The dial indicator may bear on any part of the consolidometer. Select the desired load in TSF and convert it into pounds by means of the conversion chart. Use the calibration chart furnished with each Conbel to convert load in pounds to gage reading.



16. The loading sequence is started with the selector valve forward (low range), the air regulators and the bleeder valve shut, and the low range gage shut-off valve open. The load valve must be shut (handle horizontal).

17. Slowly open the low range air regulator until the low range gage shows the desired reading. Load will be instantaneously applied when the load valve is opened.

18. To apply a higher load, first shut the load valve so that the existing sample load is maintained. Then open the low range air regulator until the gage shows the new desired reading. The new load will be applied instantaneously when the load valve is opened.

19. When the desired load exceeds the low range capacity, it is necessary to switch to the high range. First shut the load valve, to maintain the existing load. Then close the low range gage shut-off valve. (FAILURE TO CLOSE THIS VALVE WILL RUPTURE THE LOW PRESSURE GAGE.) Pull out the range selector valve to high range, and close the low range air regulator. Then open the high range air regulator until the high range gage shows the desired reading. Load will be instantaneously applied when the load valve is opened.

20. For still higher loads, first close the load valve, next set the desired gage reading, then open the load valve.

21. When it is desired to carry out an unloading sequence on either range, first shut the load valve, so that the existing sample load is maintained. Set the desired reading on the gage, then open the load valve.

22. On the unloading cycle, use the high range until the applied sample load is within the capacity of the low range. The low range may then be used for the next lower load. First shut the load valve. Then open the high range air regulator, and push the range selector in, for low range. Next, open the low range regulator until the desired reading



appears on the low range gage. Then open the low range gage shut-off valve. New load will be instantaneously applied when the load valve is opened.

23. For still smaller loads, first shut the load valve, set the desired reading, then open the load valve.